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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

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Factors Involved in Protection

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Automotive Engine Lubrication

Factors Involved in Protection

AUTOMOTIVE engine lubrication today is a marvelous tribute to the ingenuity of the designing engineer, the accuracy of production equipment and the science of petroleum refining. It is virtually a fool-proof procedure. Nothing to do on the part of the operator but add oil.

The engine lubricates itself. Oil is automatically distributed to all wearing elements, in positive and sufficient amounts to insure the constant maintenance of a protective film of lubricant to prevent metal-to-metal contact. This is not a theoretical condition, nor does it prevail in the research laboratory alone.

It is an actually existing fact in the millions of cars on the road today. Were it not so, they could not keep running.

But there are varying degrees of lubrication. It will all depend upon the care with which the original oil is selected from the viewpoint of its suitability to the type of engine, and to the operating conditions, as well as the extent to which its purity is maintained during operation.

In other words, it is not enough for the motorist to merely call for "oil" at any roadside filling station, nor should he trust to the judgment of every station employee in regard to how much his engine may require. Of course, he will get lubrication, but usually in a degree of effectiveness commensurate with his interest and the price he pays.

Rather, should he study the lubrication recommendations as developed by the oil industry and manufacturers of his particular car. Their dictates as to viscosity requirements should be given special attention. Normally this will be indicated by terminology such as "light," "medium," "heavy," etc., as part of the brand names of the oil recommended, or, perhaps the manufacturer may prefer to indicate his recommendations by the equivalent Society of Automotive Engineers viscosity numbers, such as 10, 20 or 30. These latter are indicative of viscosity as tested for at 130 degrees Fahr.

SYSTEMS OF LUBRICATION

In such a discussion of lubrication it will be of decided interest to take preliminary note of the basic constructional features of the typical lubricating systems in use today on the modern automotive engine. Broadly speaking there are two distinct types in use according to engine construction and the design of the manufacturer, viz.:

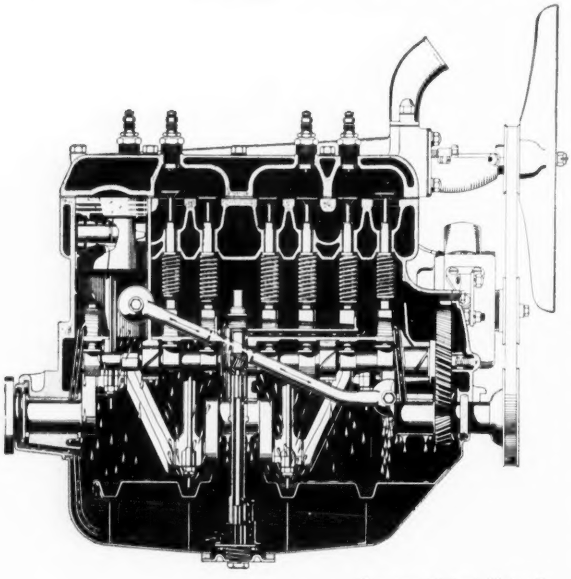
Circulating Systems	Circulating splash, Pressure lubrication, or a combination of splash and pressure
All loss systems	Mechanical force feed lubrication.

Circulating Splash Lubrication

Perhaps the simplest method from the viewpoint of lubricating equipment, piping and fittings is the circulating splash system. Some form of oil pump is normally involved in practically any circulating splash system, for auxiliary circulation of the oil which is carried at a certain level in the crankcase and distributed to the various bearings by the dipping of the connecting rods in splash troughs. In certain en-

gines the flywheel serves as the pump, circulation being brought about by its rotation, the oil being carried by its exterior surface to a suitable point of delivery to the splash troughs.

Circulating splash lubrication is essentially a form of flood lubrication. Excess oil as dis-



Courtesy of Ford Motor Co.

Fig. 1—Sectional view of the Ford Model A engine. Lubrication is effected by pump, splash and gravity feed. Note pump in base of oil reservoir, the splash troughs and flow of oil as indicated by arrows and drops.

tributed to the wearing elements by pumping or the splash action of the connecting rods drains back to the oil reservoir in the base of the crankcase to enable re-circulation.

Pressure Lubrication

The typical pressure system of lubrication as applied to the automotive engine provides for pumping of oil from the reservoir or oil sump in the crankcase directly to the main or crank-shaft bearings. From here it passes through suitably drilled holes in the crank-shaft to the crank-pins.

Oil as it passes through these latter is thrown to the cylinder walls to maintain the requisite film of lubricant thereon. The pistons and rings are thereby furnished with adequate lubrication as are also the wrist pins within the pistons.

Such a system of lubrication involves no real splashing of oil in view of the fact that there is no provision for dipping of the connecting rods, although a certain amount of oil will be thrown to the cylinder walls as stated above. All excess oil drains back to the oil sump for subsequent re-distribution by the pump.

The full pressure system of lubrication differs from the above only in that the wrist pins are also pressure lubricated, oil being delivered via drilled holes in the connecting rods or through separate tubes attached to these latter.

This oil as it passes from the wrist pins serves to supplement the lubrication of the cylinder walls as provided by the oil thrown from the crank-pins. Drainage throughout the engine is returned to the oil reservoir for redistribution.

Pressure and Splash Combined

It is practicable, however, to combine the essential features of both the pressure and circulating splash systems of lubrication. Where this is desirable the oil is pumped from the reservoir or oil sump in the crankcase directly to the main or crank-shaft bearings. Other parts are splash lubricated, as stated above.

Mechanical Force Feed Lubrication

As generally understood, mechanical force feed lubrication as employed on an automotive engine implies the continuous delivery of fresh oil to the wearing elements either individually or collectively, according to the design of the engine. Any drainage therefrom is regarded as waste though it may be collected for rough lubrication of external parts as on certain types of tractors for example.

The rate of pumping is important in the interest of economy as well as effective lubrication. As a result the oil feeds from the pump or mechanical lubricator should be carefully adjusted, observing the oil flow through the bulls' eyes or sight feed attachments.

IMPORTANCE OF VISCOSITY

The viscosity or body of an oil, as it is more generally understood by the average motorist is of considerable importance, especially under warm weather and intensive driving conditions. It has a decided effect upon oil consumption.

To realize this it is essential to appreciate that the act of lubrication requires the development and maintenance of a suitable film of lubricant on the cylinder walls and all bearings —*at the temperatures of operation.*

Normally, these latter will not exceed 300° Fahr. This is considerably below the flash point or temperature of inflammability of any reliable motor oil, hence loss or development of abnormal consumption through vaporization can generally be regarded as slight.

Viscosity Defined

Viscosity is regarded as a measure of the relative fluidity of an oil at some definite temperature of observation. In brief it is that inherent property by virtue of which the flow of certain liquids will be retarded. It is possessed by all lubricating oils to a varying degree according to their extent of refinement.

From a technical viewpoint, viscosity can also be regarded as a measure of the resistance which the particles or molecules of an oil will offer to one another as they come into contact in circulation through the lubricating system or between the wearing elements. Viscosity will vary inversely with temperature, i.e., the colder an oil the heavier or more sluggish will it be. In contrast it will become more and more fluid as the temperature is raised.

Reasons for Higher Viscosity Requirements

Modern conditions of higher automotive engine temperatures will lead to an increase in the degree of fluidity of the motor oil which is used for lubrication. Especially will this be true in warm weather, when the amount of external cooling will be appreciably lower than in cold weather.

The utmost care must therefore be taken in the selection of the proper grade of motor oil for warm weather operation in accordance with chart recommendations. Haphazard choice may be the forerunner of too great a reduction in the fluidity of the oil in service, with oftentimes ineffectual lubrication of certain of the wearing parts of the engine as well as abnormal increase in the rate of consumption. The ultimate occurrence of scored or burned out bearings, of abnormal wear on cylinder walls, and an excess of oil pumping past the piston rings, will all lead to increased cost in car maintenance and a natural decrease in power output.

Oil Gauge Pressure

In this connection oil pressure as shown by the dash gauge must also be considered. The function of this gauge is essentially to indicate that engine lubrication is being maintained. It is not a means of determining the amount of oil delivered to the various wearing parts, but rather the resistance to pumping involved.

Oil gauge pressure will therefore vary according to the viscosity or relative fluidity of the oil. Oil pressure drop will frequently cause worry to many motorists. It should, however, only be regarded as an indication of impaired lubrication provided pressure is lost entirely, for this may mean a broken or inoperative pump.

With the natural reduction in body or viscosity which is attendant to normal engine operation, resistance to pumping will be proportionately reduced. A certain amount of drop in pressure, especially during intensive or warm weather driving should, therefore, be expected.

In other words, the lighter the oil, the more easily will it pump and circulate, requiring less pressure. Reduction in body or viscosity may be accomplished by heating or dilution. As a result, if oil pressure drops too low it will be an indication that the viscosity of the oil is too low to meet the operating temperatures involved. The reason may be that originally the oil was

Courtesy of A C Spark Plug Co.

Fig. 2—Cutaway view of the A C oil filter. Dirty oil enters under pressure at 1; is forced into tubular passage of filter bag 2; dirt being left on inside of this bag. 3 indicates clean oil passing through a cylindrical supporting screen for the filter bag. At 4 clean oil enters tank to pass via sight gage back to crankcase at 5.

too light, or that an excess of dilution has occurred.

The remedy is, of course, to use more care in original selection of the oil according to chart recommendations, and to operate with as lean a fuel mixture as possible. Reduced choking, the least amount of idling, and bringing an engine up to operating temperature as soon as possible after starting will all aid largely in this regard.

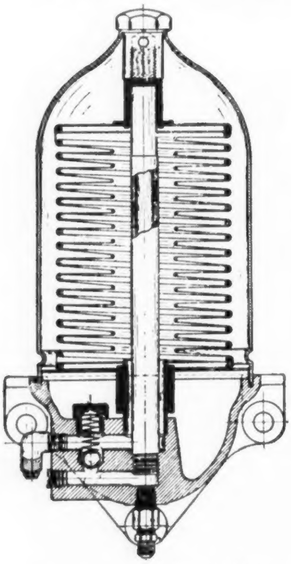
It will be obvious, therefore, that high or rising gauge pressure should be of far more concern to the motorist, for it may be an indication of faulty lubrication due to a clogged oil line, or the oil being too sluggish and heavy to pump readily and distribute freely to the bearings, or splash to the cylinder walls, according to the type of lubricating system involved.

Definite Information Necessary

In view of the importance of the viscosity characteristic, and the attention which should be given to it by the motorist when buying motor oil he should be informed both as to the method of test and the range limitations for the several accepted grades of motor oils. In other words, he should know the approximate range

of viscosity involved when he buys a grade of "heavy" motor oil, for example, regardless of who it is manufactured by.

Furthermore, he should know that when an oil is stated as having a viscosity of say, 65



Courtesy of Motor Improvements, Inc.

Fig. 3—Details of type B-1 Purolator designed for crankcase oil filtration. The filter element contained within a shell, can be easily removed for cleaning when necessary.

seconds Saybolt at 210° Fahr., this means that the body or relative fluidity of the oil in question is such that, at a uniform temperature of 210° Fahr., it will take 60 cubic centimeters of this oil 65 seconds to flow through the orifice of the standard Saybolt viscosimeter.

With such knowledge he can frequently detect any attempt to "put over" improperly refined oils which may be way out of line in regard to the "operating viscosity" requirements of his particular engine.

THE EFFECT OF CARBON RESIDUE

Carbon is an essential component of all petroleum products, and therefore must pass through every automotive engine. It is only a detriment, however, in the form of soot or deposits of carbonaceous tarry matter. This may of course have a very decided effect upon the operation of the engine, the amount of power developed and the amount of "knocking," according to the extent to which carbon deposits are formed on the spark plugs, pistons, cylinder heads, around the rings, on valves and valve seats, and in the crankcase.

Heat a Factor, as well as Nature of Lubricant

The amount of ultimate carbon will depend entirely upon the degree of heat present, the extent of refinement of the lubricant and the base of the crude from which it is made. From particular types of crude for example, distillates can be produced which will show an almost negligible carbon residue, 0.05 being a fair idea of the amount to be expected. The use of residual oils, however, for the purpose of blending and increasing the viscosity may easily raise the carbon residue percentage of the resultant product to one per cent or above. Lubricants of this nature will be dark green in color and comparatively opaque.

Carbon which is developed from blended oils containing residual products will, as a rule, be harder and more abrasive than carbon from lubricants of equal viscosity, but which are wholly of a distilled nature. Hard abrasive carbon does its greatest damage as a promoter of wear on cylinder walls and bearings. Most frequently will it be developed on the upper part of the cylinder walls to be retained by the lubricating film and ultimately worked past the piston rings and into the lubricating system.

All true carbonaceous deposits in the average automotive engine do not, of course, originate from the lubricating oil. Incomplete combustion of the gasoline or an abnormal amount of dilution of the lubricating oil will also tend to increase the amount of carbon formation in the combustion chamber. In other words, the lighter the lubricant or the thinner the film on the cylinder walls, the more readily will it splash or succumb to the wiping effects of the piston. This will, of course, increase the possibility of pumping or forcing of the lubricating film up into the combustion chamber where it will be ultimately burned. The direct result is the development of more or less carbon.

How extensive these deposits may be will, of course, depend upon the residual carbon content of the oil. Where the latter burns cleanly the amount of such deposits will be relatively small. Furthermore, if the oil is properly refined and adapted to the purpose such carbonaceous matter will be soft in appearance, low in quantity and easily removed when cleaning is necessary. Over extended periods of operation, however, carbon deposits whatever their nature, will be bound to increase.

How Excess Lubricating Oil May Act

Just how an excess of lubricating oil may cause abnormal carbon deposits will be of interest. Theoretically a very small amount of oil is necessary to maintain the requisite lubricating film on the cylinder walls and serve the respective bearings; actually, however, a considerable excess of oil will be used. Where the rings give the proper degree of seal and the

cylinder walls are not abnormally worn, but little of this oil should pass to the combustion chamber. If the oil level is carried too high, however, especially in oiling systems involving splash lubrication, the amount of oil on the cylinder walls may be so excessive that a certain percentage cannot help but find its way into the combustion chamber. A smoky appearance of the exhaust will frequently be an indication of this.

Lubrication Protection

Once attained, lubrication must, of course, be protected. In other words, we must guard against its impairment by entry of abrasive foreign matter or materials which may interfere with the functioning of the lubricating system.

This will require:

(a) Reduction in the development of carbonaceous matter when lubricating oils are exposed to high operating temperatures on the upper parts of the cylinder walls and pistons.

(b) Prevention of entry of abrasive dust along with the air which is essential to combustion, and

(c) Counteraction of dilution of the main body of oil in the crankcase by unburned gasoline ends which may leak past the rings.

To a certain degree all this can be accomplished by improvements in engine design, to promote more complete combustion with better control of temperatures.

Requirements for simplicity of construction, however, indicate that in all probability the use of accessory equipment for the prevention of entry of dust, and the removal of carbonaceous matter, dirt, metallic particles and heavy gasoline ends and water of condensation, will be probably the most practicable.

Excellent results will be attained in this regard by the employment of such means to purify or filter the oil in its course through the engine, to filter the air for combustion prior to its passage through the carburetor, and to remove or distill off any water vapor that may have condensed in the crankcase, or any gasoline that may have leaked past the piston rings to dilute the oil therein.

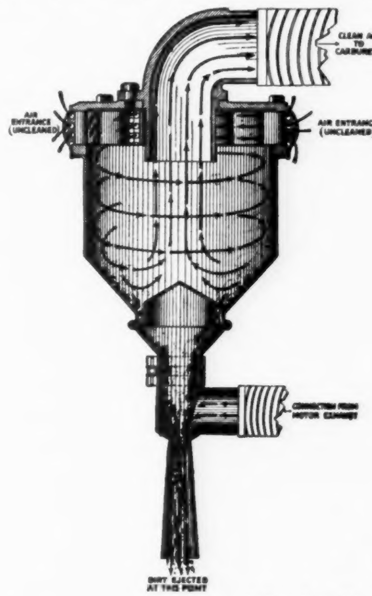
The oil filter is perhaps the more essential of these devices, for the extent to which air may contain abrasive dust particles will depend to a great extent upon the character of the roadway and adjacent country.

There will, however, always be a certain amount of contamination in motor oil after a certain length of service in an engine. Abrasive dust may pass in through the crankcase breather, break-down of the oil or overchoking may develop carbonaceous residues, and there will always be the possibility of minute metallic particles being worn from the interior parts of the engine.

OIL FILTRATION IN SERVICE

Effective filtration or purification of motor or bus oils in service can be expected to lead to the same beneficial results in improved lubrication, as similar treatment of steam turbine or Diesel engine oils. Defective lubrication is more frequently the result of contaminated lubricants, and the inability of the latter to perform their intended function, rather than of faulty refinement, provided, of course, that the original oil conforms in characteristics to the specifications demanded by engine construction and the operating conditions involved.

To, therefore, endeavor to protect the automotive engine by removal of dust, dirt or metallic foreign matter from the oil, is decidedly advisable.

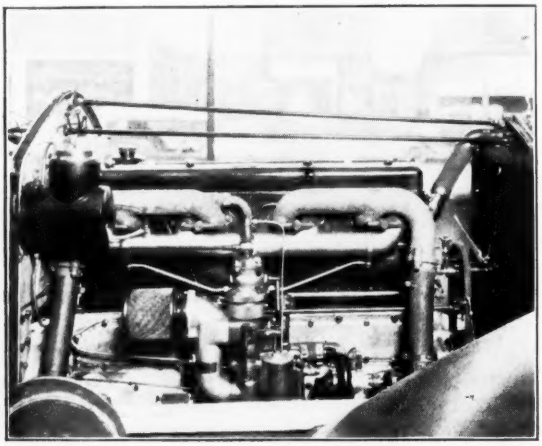


Courtesy of Stromberg Motor Devices Co.

Fig. 4—The Stromberg centrifugal type of air cleaner with upward path of air indicated by arrows. Dust and dirt passes downward as shown.

The properly designed oil filter should accomplish this. To expect, however, that the oil filter as applied to individual treatment of

automotive engine oils will insure indefinite longevity in the latter is erroneous. For the oil filter cannot be absolutely perfect, nor can it adequately remove all of that very fine carbonaceous content which is the natural result



Courtesy of Air-Maze Corp.
Fig. 5—An Air-Maze cleaner installed on an engine. The principle of this type of air cleaner is known as baffling impingement, air being passed through specially designed screen wire. Effective filtration is possible at all engine speeds.

of subjecting such oils, today, to the usual temperatures of combustion.

Filtering Does Not Eliminate Necessity for Oil Renewal

Oils do not break down, but there is a tendency towards incomplete combustion of oil and gasoline to a certain extent at the hottest part of the cylinder walls. The residue, being carbon, is of naturally a discoloring nature, hence the rapid darkening of the new oil when put into service. Furthermore, carbon has but a negligible lubricating value; in fact, if hard and abrasive, it may easily lead to scoring of wearing elements.

As a result, motor oils require the addition of makeup. Furthermore, they require frequent replacement, in the interests of protection of the more valuable engine wearing parts, however effective filtering may be.

In addition, we must remember that oil filters in service are constantly accumulating solid foreign matter. To an extent this will improve filtering efficiency. Rate of oil flow will be reduced, however, dependent upon the thickness of the deposit. Ultimately filtering efficiency will likewise be affected. Filters should, therefore, not be regarded as eliminators of the necessity for periodic crankcase draining, although, in efficient condition they may rightly be expected to lengthen this period and increase the mileage value of an oil to a certain extent.

AIR CLEANING

Provided that motor or bus oils of the requisite degree of purity are used, that is, oils which develop a minimum of hard carbon, it is evident that engine lubrication will be improved if steps are taken to insure the use of as clean air as possible. With this object in view, considerable attention had been devoted to the development of suitable air cleaners or filters.

By properly passing the air necessary for combustion purposes through a filtering or separating medium capable of removing the greater part of the road dust content, more efficient lubrication of automotive engine parts with proportional reduction in abrasive wear should result.

Amount of Dust Will Vary

The amount of dust which may ultimately gain entry into an automotive engine will, of course, depend first of all upon whether or not an air cleaner is installed, and then, upon the location, and efficiency of this latter. Of course, there are also certain other influencing factors, such as, for example, the nature of the soil of the country being traversed, the amount of wind, the running speed, the type and size of fan installed, and the tightness of its belt.

Courtesy of United Air Cleaner Co.
Fig. 6—Details of the United air filter which uses a combination of centrifugal and centripetal force to eject dust and dirt from the air entering the carburetor.

It is safe to say that research as carried out to date is indicative of the ultimate value of an air cleaner on practically any type of automotive engine. In motor bus or truck service this will probably be particularly true, inasmuch

as the degree to which business will prosper will depend upon the extent to which equipment is kept on the road.

Cleaners Must Themselves Be Clean

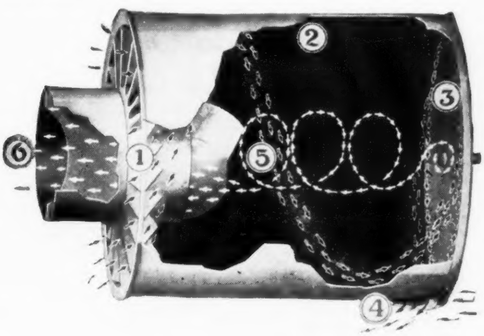
It is well to bear in mind, however, that some air cleaners will require periodic cleaning themselves. To merely install such a cleaner and forget it, in the assumption that it will function indefinitely is erroneous. Unless the dust content which has accumulated is removed periodically, the cleaner may ultimately fail entirely in its intended purpose, or even in some cases lead to an increased amount of abrasive dust gaining entry to the engine. Furthermore, in certain types of air cleaners, congestion may result in an enriched mixture of gas and air passing to the carburetor, due to reduction in volume of air available. There are other types of cleaners, however, which are self cleaning.

CRANKCASE DILUTION AND ITS EFFECTS

The extent to which crankcase dilution will occur in an automotive engine will depend upon the type involved, the power developed, the temperatures of operation and the amount of choking which is necessary especially on starting when the engine is cold. It will usually be more prevalent in the average pleasure motor car, than in the heavier powered engine of the bus or truck where operation is more continuous, and the engine hotter.

Cause

Crankcase dilution or the thinning down of a motor oil, is normally due to condensation or deposition of a certain amount of unburned

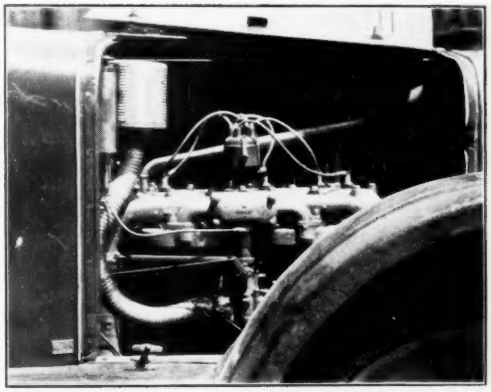


Courtesy of A C Spark Plug Co.

Fig. 7—An air cleaner of the A C type which employs centrifugal force. At 1 suction stroke of motor draws in dust laden air. 2—centrifugal force separates out dust particles. 3—spiral movement of dust particles carries them to point of ejection at 4. Clean air is indicated at 5, passing to the carburetor via outlet at 6.

fuel on the cylinder walls. This eventually reaches the crankcase to enter the lubricating system, on account of the continued interchange of freshly sprayed oil with the oil film on the cylinder walls.

As a detriment dilution may involve impaired lubrication, due to the body or relative fluidity of the oil being too low at bearing operating temperatures to maintain an effective film between the wearing elements. Metal-



Courtesy of Staynew Filter Corp.

Fig. 8—An automotive engine equipped with a Protectomotor air filter which uses felt fabric for removal or filtering out of dust.

to-metal contact with the development of abnormal friction may thereby result. Furthermore, the delivery of too thin an oil to the cylinder walls may lead to blow-by on account of imperfect sealing.

Normally, however, there is little probability of bearings being actually burned out, because the viscosity of the lubricant has been reduced to the extent that it would be under average cases of crankcase dilution. Any number of instances are on record where motor trucks have experienced dilution to the extent that their crankcase oil was decreased to less than one-fifth of the original viscosity. Yet they operated effectively and on examination their engine bearings showed practically no ill effects. When trouble is experienced it will usually be due to abnormal operating conditions. It can be appreciated, therefore, that dilution has been over-stressed.

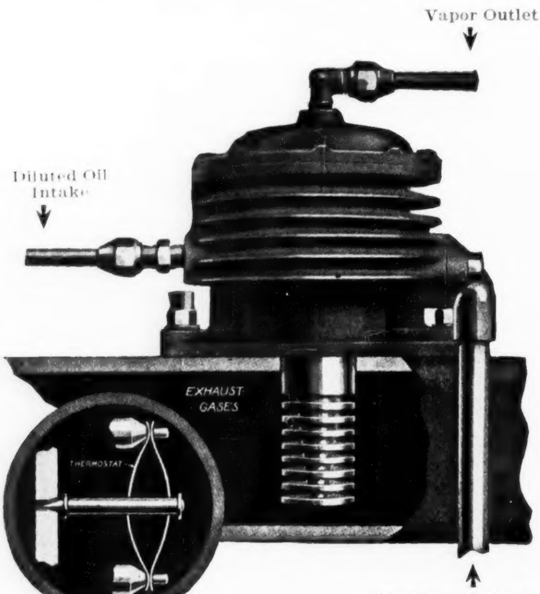
Effect of Engine Temperatures

Dilution is generally regarded as being intimately influenced by the engine temperature. In other words, the temperature of the cylinder must be sufficiently high to insure complete vaporization and burning of this fuel. Otherwise certain of the heavy ends or fractions of low volatility will remain unvaporized.

Of course, when the engine is operated under average conditions of atmospheric temperature or after it has come up to its own normal temperature of operation there will be little or no difficulty experienced in vaporizing the average grades of gasoline. Under relatively cold engine conditions, however, the amount of gasoline which will be vaporized will normally be decidedly lower.

Reason For Choking

This difficulty can be overcome to a certain extent by choking or manipulation of the carburetor in order to increase the richness of the mixture, or obtain approximately the requisite percentage of fuel in the form of gas by reduc-



Courtesy of Skinner Automotive Device Co., Inc.
Fig. 9—The Skinner Model C Oil Rectifier. As the engine operates diluted oil is passed through this device being refined by exhaust heat, and returned to the crankcase by gravity. The vapors pass to the intake manifold.

ing the amount of air delivered to the carburetor on starting.

Carburetors are normally adjusted when hot in order to obtain good fuel economy, and to decrease dilution; hence a certain amount of control by means of the choke is made necessary in order to meet cold weather conditions as mentioned above.

Choking, however, while it facilitates starting a cold engine, is also conducive to increased dilution inasmuch as under such conditions less of the gasoline will vaporize than when operating under normal temperatures. As a result, considerably more of the higher boiling point fractions will remain in liquid state, to leak past the piston rings and either wash the film of lubricating oil from the cylinder walls or become so incorporated with this film that consequent reduction in viscosity will result.

Design of Engine a Factor

Dilution will also vary to a certain extent with the design and mechanical condition of the engine. Where an engine is designed especially to burn a certain grade of gasoline the possibility of dilution occurring will be decreased. This is also true where provision is made to keep the oil temperatures relatively high.

While but little has been done in installing provisions for heating the lubricating oil in the crankcase of the average car to-day, in practically every other way effort has been made to design engines so that the least amount of dilution will occur. As a result a tractor engine designed to burn kerosene should show no more dilution than an automobile engine designed for gasoline of considerably higher volatility. The increased temperature of operation in the event of heavy service will decrease the rate of dilution to a certain extent by virtue of the fact that the so-called heavy ends of the fuel will be more completely vaporized and burned. Carburetor adjustment will also play an important part.

Means of Counteraction

Dilution may be counteracted by care in operation, or by the installation of mechanical means for its correction. In the first case, its actual occurrence is reduced; in the second it is assumed as having occurred, the procedure being to remove the fuel and more or less water from the lubricating oil by the process of distillation.

The installation of suitable means for crankcase ventilation, and provision for cooling water temperature control have also been proven to markedly reduce the development of dilution in operation.

After occurrence the practicable method of accomplishing its reduction is by distillation.

In one device oil plus gasoline and any water is passed to a chamber wherein it is subjected to the heat of the engine exhaust. Properly controlled, this latter will be adequate to distill off any water, or gasoline ends, leaving the oil content in undiluted state.

Another device for removal of crankcase dilution includes also means for filtering the diluted oil. This is done prior to distillation. In operation the oil as drawn from the engine is first passed through a suitable filtering sack containing asbestos. It is then led to the distilling section of the apparatus where contained water and gasoline ends are driven off by virtue of the heat of the exhaust which is applied, leaving the oil in condition to maintain most effective lubrication.

Oil Flow Must Be Regulated

In the operation of any equipment designed for reduction of crankcase dilution by a process of distillation, it is necessary to observe care in regulating the rate of oil flow. It can be appreciated that exhaust temperatures, which are used to bring such crankcase oil to a point of

distillation whereby water and gasoline ends will be removed, may vary widely.

It is, of course, with higher temperatures that the operator must concern himself. Here the possibility of "cracking" or rapid oxidation of the oil itself must be guarded against, especially if the latter is exposed to such heat for too long a period.

Water a Detriment

Water in the crankcase or oil sump of an automotive engine will be conducive to rust, ice, emulsification and sludge formation. This will be especially true in cold weather or where road dust, dirt, carbon or metallic particles have been allowed to accumulate to any extent.

The oil filter and air filter have already been spoken of as factors in this regard. But above all, and especially in cars not equipped with these accessories, it is important to remember that periodic changing of oil and careful flushing of the crankcase and lubricating system will be most advisable in the interests of prolonging the life of bearings and piston rings, the prevention of undue wear on cylinder walls and the assurance of more dependable operation.

Why Water is Present

Just how water may gain entry into such a carefully built and enclosed machine as an automotive engine will be of interest. The possibility of entry from an external source is remote, provided reputable gasoline and motor oil are used which can be depended upon to be water-free. Far more frequently will it be developed within the engine itself, as a product of combustion or condensation.

Dependent Upon Condition of Engine

As a product of combustion, the subsequent degree to which water may find its way into the lubricating system will depend upon the condition of the engine. In other words, where piston rings are worn or cylinder walls scored or abraided to result in abnormal clearance, an effective seal cannot be as readily maintained by the lubricating oil as in an engine where the proper clearance exists between the pistons and cylinder walls.

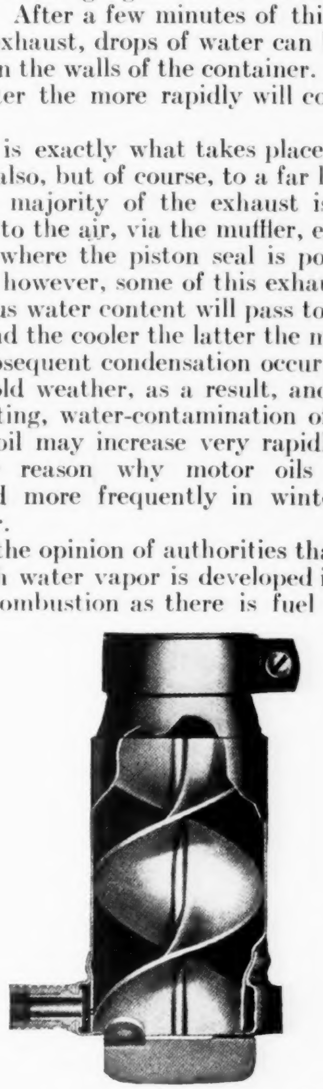
High clearances will be conducive to leakage. A number of detriments may thereby result. For example, loss of compression may occur through blow-by, or leakage of combustible fuel vapor on the explosion stroke.

There will also be the possibility of water leakage past the piston rings and into the crankcase. The extent to which water may be developed in the process of combustion can be realized by holding a glass receptacle over the end of the exhaust. The exhaust as it passes to the air is usually gaseous in form, though a certain amount of saturation may occur through partial condensation in the muffler. In gaseous form water cannot be as readily observed; hence the idea of using a glass to serve as a crude condenser. After a few minutes of this collection of the exhaust, drops of water can be actually noted on the walls of the container. The colder the latter the more rapidly will condensation occur.

This is exactly what takes place within the engine also, but of course, to a far less degree, for the majority of the exhaust is naturally carried to the air, via the muffler, except in an engine where the piston seal is poor. At all events, however, some of this exhaust with its vaporous water content will pass to the crankcase, and the cooler the latter the more readily will subsequent condensation occur.

In cold weather, as a result, and especially on starting, water-contamination of the lubricating oil may increase very rapidly. This is another reason why motor oils should be changed more frequently in winter than in summer.

It is the opinion of authorities that virtually as much water vapor is developed in the process of combustion as there is fuel consumed.



Courtesy of Rectifier Mfg. Co.

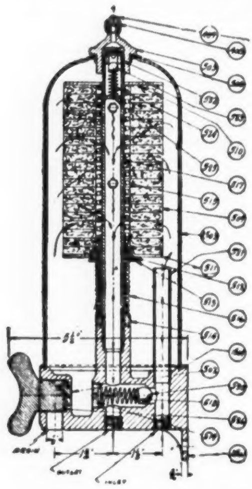
Fig. 10—Details of construction of the Remington centrifugal type air cleaner which also serves as a crankcase ventilator. Dust is collected on the spiral which is oil coated.

How much of this will ultimately reach the crankcase to mix with the oil therein as actual water will of course, depend on how effectively the piston rings and lubricating film function in the maintenance of a suitable seal. It would be unwise to attempt to give a figure in pints

of water for example, per gallon of gasoline, or per hour of operation; there are too many variables involved as already stated.

Condensation From the Air

Water, of course, may also be condensed from the air within the crankcase, for under



Courtesy of Sheet Steel Products Co.

Fig. 11—The H-W Filtrator in detail. An advantage of this type of oil filter is that it does not lead to loss of oil pressure. The filtering element is animal fibre which does not disintegrate when exposed to petroleum hydrocarbons. Numbers refer to individual parts.

normal conditions of design air has full access through the crankcase breather.

Here again the variables involved will preclude even an approximate estimate of how much water to ultimately expect. It will depend upon the moisture content of the air, the weather, the altitude, the atmospheric temperature, the frequency of starting and stopping and the extent to which the engine actually becomes properly heated.

Condensation from excessively moist air may, of course, also occur within the gasoline tank, especially where the amount of air in the tank is high and where the car is stored in a warm garage and then driven out under comparatively low atmospheric temperatures. This factor must be considered even where the highest grades of gasoline are used.

Under widely varying temperatures condensation and development of water in the gas tank will be most prevalent, and in winter more so than in summer.

Water in the Gasoline

The presence of water in gasoline should be carefully guarded against in cold weather operation, due to the possibility of its giving trouble by freezing in the gasoline pipe, carburetor, or even the bottom of the storage tank. Should a drop of water come in contact with the fine mesh strainer located in the fuel line it may entirely cover the mesh with a film. Freezing of this film which might happen even when immersed in the fuel, would cause a stoppage in the flow of gasoline perhaps even to the extent of shutting off the entire supply.

To locate the source of such trouble while out on the road might be a difficult matter, as the frozen film covering the screen may not be readily apparent to the eye, and considerable labor and time would no doubt be involved before the cause of the stoppage in the fuel line could be ascertained. Even if such a film of water did not freeze there would still be the possible objectionable feature of misfiring.

Indication of Water

Water in the carburetor is indicated by misfiring. In this event the carburetor drain should be opened to remove any slugs of water that may be present. It would also be advisable for the motorist to thoroughly inspect his tank for the presence of water at the earliest opportunity, and to drain the gasoline from the system and strain it.

Separation of Water

Unless a device specifically designed for removal of water from the oil in service is installed, emulsification and sludge formation can be the normal expectation. But these developments will, of course, not occur as rapidly with new or comparatively fresh oil as later on when the oil has been in service for perhaps several hundred miles.

In other words the extent to which water will be held in suspension will depend upon the degree of contamination of the oil from other sources. The higher the degree of purity the more readily will emulsions be dissipated and water precipitated to the bottom of the crankcase or oil sump. Draining off of perhaps a pint from this latter every hundred miles when the engine is cold and adequate precipitation has occurred, should be a factor in keeping down water and foreign matter accumulation and the development of serious sludging. It is not a difficult procedure and is certainly worth the time and trouble required, especially where a comparatively costly engine is involved or where continued service is desired with maximum reduction in time lost or upkeep expense.

Water, the Cause of Rust in a Cold Engine

In view of the fact that under average operation in cold weather the occurrence of condensation, the retention of an abnormal amount of water in the engine, and its ultimate presence on the cylinder walls and in the crankcase oil will be prevalent, rust formation, where such an engine is allowed to stand for

any length of time will be practically inevitable, for under comparatively low temperatures cylinder walls will not be completely dried off after stopping.

Research has indicated, however, that if provision is made to maintain the temperature of the engine cooling water sufficiently high (i. e. in the neighborhood of 180 degrees F) this possibility of rusting will be decidedly reduced. In effect this amounts to using means to prevent the engine and crankcase from cooling down abnormally when standing. This can be partially accomplished by covering of the radiator, storage in a warm garage, or jacketing of the crankcase. This latter, however, as a preventive of lubrication difficulties is still in a state of experimentation.

Another effective means of reducing the possibility of rust formation and water accumulation on cylinder walls especially, is to provide for adequate means of serving the cylinders with an abundant supply of oil on starting. Elimination of the by-pass valve in cold weather and use of motor oils of relatively high fluidity will help to accomplish the desired results.

Sulphur and Its Effects

In connection with water and sludge formation the question of the subsequent development of corrosive sulphuric acid will also require consideration.

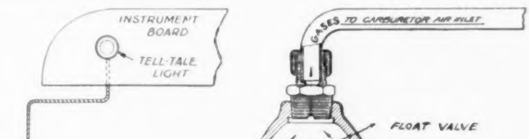
The extent to which acidity may prevail in a motor oil will largely depend upon the nature of the fuel used, and the sulphur content of the latter. In a high grade straight distilled gasoline of 0.10 per cent sulphur content or below the detrimental results will be virtually negligible. Where blends involving benzol are used, however, in an effort to improve antiknock qualities for example, the sulphur content of the resultant fuel may be decidedly marked, running frequently as high as 0.20 to 0.30 per cent.

The sulphur content of certain crude oils will also vary widely. Where relatively high, the subsequent sulphur content in any gasoline derived therefrom will be proportionately high. It is, therefore, decidedly essential for the oil refiner to use the utmost care in the choice of crudes from which to manufacture his gasolines.

Sulphur as a constituent of straight distilled gasoline, or of benzol will normally be present as a more or less complex compound of the other chemical elements involved. Rarely will it occur as essentially free sulphur.

The process of combustion, however, will have the same effect in either case. Oxidation will bring about the formation of sulphur dioxide (SO_2). This latter is a gas of highly reactive tendencies especially in the presence of water vapor. In view of the amount of water vapor which as has been already shown, is developed during combustion, its ultimate reaction with sulphur dioxide to form sulphurous acid (H_2SO_3) is a normal consequence.

In other words, we have the genesis of corrosion, for while sulphurous acid is comparatively weak, it is also unstable from the viewpoint of oxidation, i. e., it can be ultimately expected to take up one more atom of oxygen to bring about the formation of sulphuric acid, a far more highly corrosive product. Oxidation of sulphurous acid is hastened of course, by heat and in the presence of air and metallic particles.



Courtesy of Rectifier Mfg. Co.

Fig. 12—Sectional view of the Wall oil rectifier. In addition to involving a process of distillation, this device also includes an asbestos filter, through which the oil to be purified must pass, prior to being exposed to the heat of the exhaust gases in the distilling chamber.

In an engine under operation, where blended gasolines, or straight run fuels from uncertain sources, are used, corrosion from sulphuric acid may be a highly potential possibility. The extent to which engine bearings and other wearing elements may be damaged will,

of course, depend on how continuously such fuels are used, and the degree of seal which is being maintained by the piston rings.

Corrosion More Prevalent in Cold Weather

Research has developed that corrosion due to sulphur reactions will probably occur more readily in cold weather, due especially to the greater possibility of abnormal condensation of water vapor developed in the process of combustion. It is logical to presume, therefore, that effective means for reduction of condensation will reduce the possibility of active chemical reaction with sulphur. This can be brought about by preventing cooling down of the engine to an abnormal degree, especially during intermittent operation. Suitable radiator covering, installation of shutters, the use of a thermostat in the cooling system, and means to insure proper crankcase ventilation are all regarded as of marked advantage in this regard, especially if used in combination with one another.

ACIDITY AFFECTS SLUDGE FORMATION

Sludge formation in the crankcase has been briefly mentioned in the discussion of the detrimental effects of water. It is also hastened by acidity in the motor oil. With properly refined lubricants acidity is a negligible factor when they are new. In service, however, wherever sulphuric acid as a product of combustion may leak past the piston rings to enter the lubricating system, the development of sludge, especially where high water content has brought about emulsification will be highly probable.

Emulsions alone are certainly not as viscous, adhesive and generally objectionable as insoluble sludges which so frequently clog oil passages, congest the oiling system and generally reduce the lubricating quality of the oil.

Two Stages Involved

Sludge is generally agreed upon as passing through first the soluble stage, and then the insoluble stage.

Where water is present, fairly stable emulsions may be formed. On the other hand, the presence of an emulsion is not necessarily indicative of sludge.

Emulsions, if uncontaminated and unoxidized, will clarify themselves and precipitate water on standing, leaving the bulk of the oil in very nearly the same condition as prior to agitation.

Soluble sludges, however, at temperatures above approximately 100 degrees F. will be held in suspension in the oil. Yet while both emulsions and soluble sludges can be apparently readily dissipated from, or absorbed by, the oil, they are nevertheless a detriment to lubrication while present, due to the fact that the formation of a continuous, uniform oil film over the surface to be lubricated is impaired.

Reduction of Sludge Formation

It may generally be assumed that sludge is the result of a cumulative reaction. In other words, once developed, unless it is completely cleaned from the crankcase at the period of engine flushing, it will immediately form the basis for development of emulsification and sludge formation in the fresh oil.

The crankcase and lubricating system should therefore be carefully cleaned at each period of oil change. It is difficult to detect sludge, except by careful laboratory examination of used oil. For the average motorist to tell whether or not it may be present in his engine is virtually impossible. Hence the advisability of being on the safe side and seeing that an engine is always properly flushed and cleaned with warm, light motor or flushing whenever oil is to be changed.

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